*3rd Joint HiLumi LHC-LARP Annual Meeting*
*November 11th-15th, 2013*
*Daresbury Laboratory - Warrington, UK*

# Summary of LHC Collimation session

*R. Appleby, R. Bruce, A. Lechner, R. Kwee, J. Jowett, L. Lari, T. Markiewicz, A. Marsili, N. Mounet, S. Redaelli, J. Resta-Lopez, W. Scandale, M. Serluca, N. Simos, G. Stancari, for the Collimation Project and HL-LHC-WP5 teams*

SEVENTH FRAMEWORK PROGRAMME

High Luminosity LHC

*The HiLumi LHC Design Study is included in the High Luminosity LHC project and is partly funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404.*

LHC Collimation Project

CERN

# Outline

- Introduction: HiLumi-WP5
- HiLumi-WP5 activities
- Other collimation activities
- Conclusions

# WP5 structure and membership

**WP5.1: Coordination & Communication**

**WP5.2: IR Simulations of Halo Loss**

– Assess locations and magnitudes of halo loss in the IR's for various upgrade scenarios (includes crab cavities, ATS, ...).

– Assess impact of imperfections.

**WP5.3: IR Simulations of Energy Deposition**

– Assess locations and magnitudes of energy deposition in the IR's for various upgrade scenarios.

– Assess impact of imperfections.

**WP5.4: Design of IR Collimation**

– Study required collimation to keep losses at the same level or below before the upgrade.

– Integration of collimators, new layout and optics.

– Feed-forward to simulation WP's.



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GAP

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# Recap. of deliverables

D5.1) Simulation models for beam loss: Set up of simulation models for beam loss halo that correctly describe the halo, the optics and the available LHC aperture after an upgrade. Some of the simulations must allow high statistics of primary beam halo (5-20M protons). (Task 5.2) [month 12] — DONE

D5.2) Simulation models for energy deposition: Set up energy deposition models that correctly describe the IR1 and IR5 geometries after the upgrade. Define appropriate interfaces to experiments. (Task 5.3) [month 12] — DONE

D5.3) Beam halo simulations: Simulate and compare beam loss in IR1 and IR5 for various scenarios of halo and upgrade changes. Verify that an upgrade scenario has acceptable beam loss characteristics. For the verified scenarios provide input to energy deposition and other studies (Task 5.2) [month 18] — DONE

D5.4) Energy deposition simulations: Simulate and compare the local energy deposition for both upgraded IRs. If more than one qualified scenario exists, compare the different scenarios. Generate input to background studies for the experiments. (Task 5.3) [month 24] — UPCOMING

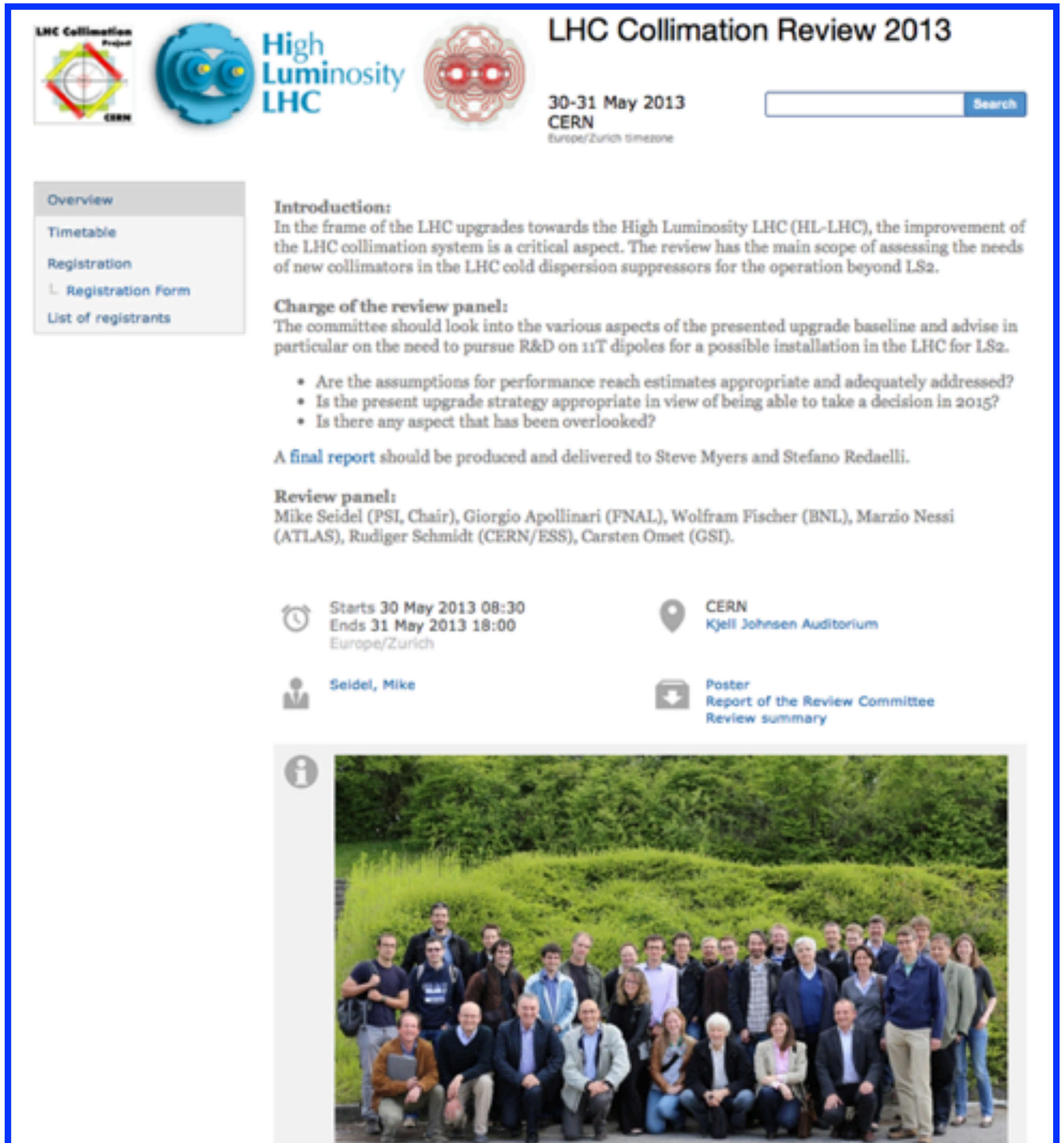
D5.5) Conceptual design IR collimation: Given the simulated halo loss and energy deposition, work out conceptual designs for upgraded IR collimation systems in IR1 and IR5. (Task 5.4) [month 36]

D5.6) Technical design IR collimation: Study and simulate the conceptual solution of IR collimation for IR1 and IR5. Verify the solution versus various engineering constraints and develop it into a technical design. Iterate if needed. (Task 5.1 using inputs from 5.2, 5.3 and 5.4) [month 42]

D5.7) Design report and functional specification: Provide a design report for the upgraded collimation systems in IR1 and IR5. Provide functional specifications for any additional collimators and absorbers that are required in the upgraded systems (Task 5.1 using inputs from 5.2, 5.3 and 5.4) [month 48]

(DONE means done formally, but of course ongoing for us)

# Collimation review outcome




https://indico.cern.ch/event/251588

**External review panel:**
Mike Seidel (PSI, Chair), Giorgio Apollinari (FNAL), Wolfram Fischer (BNL), Marzio Nessi (ATLAS), Rudiger Schmidt (CERN/ESS), Carsten Omet (GSI).

**Main outcome on DS collimation:**
Due to the **uncertainties on the extrapolations of beam lifetime and quench limits at 7 TeV**, "The committee strongly encourages the development and prototyping of one 11 T (5.5 m) dipole magnet, and the cryogenic bypass collimator unit. … Build at least 4 units (1 unit consists of 2 magnets + bypass + collimator) since this would cover 2 possible cases…"
Additionally: **support for reduced impedance collimators and hollow elens works!**

# Collimation review outcome


LHC Collimation Review 2013

30-31 May 2013
CERN
Europe/Zurich timezone

Overview
Timetable
Registration
Registration Form
List of registrants

**Introduction:**
In the frame of the LHC upgrades towards the High Luminosity LHC (HL-LHC), the improvement of the LHC collimation system is a critical aspect. The review has the main scope of assessing the needs of new collimators in the LHC cold dispersion suppressors for the operation beyond LS2.

**Charge of the review panel:**
The committee should look into the various aspects of the presented upgrade baseline and advise in particular on the need to pursue R&D on 11T dipoles for a possible installation in the LHC for LS2.

- Are the assumptions for performance reach estimates appropriate and adequately addressed?
- Is the present upgrade strategy appropriate in view of being able to take a decision in 2015?
- Is there any aspect that has been overlooked?

A final report should be produced and delivered to Steve Myers and Stefano Redaelli.

**Review panel:**
Mike Seidel (PSI, Chair), Giorgio Apollinari (FNAL), Wolfram Fischer (BNL), Marzio Nessi (ATLAS), Rudiger Schmidt (CERN/ESS), Carsten Omet (GSI).

Starts 30 May 2013 08:30
Ends 31 May 2013 18:00
Europe/Zurich

CERN
Kjell Johnsen Auditorium

Seidel, Mike

Poster
Report of the Review Committee
Review summary

https://i

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***The review panel*** *recognized that DS collimation:*
*- is needed for ions in IR2/1/5, already in LS2 (ALICE upgrade).*
*- is probably **not** needed in LS2 but we cannot guarantee that at this stage.*
*- is certainly beneficial for the HL-LHC era (ATS optics).*
*- this technology will be clearly useful for the HL-LHC era*
*Recommendation to work hard to achieve a minimum of 4 by LS2!*

# WP5 agenda at Daresbury

| | | |
|---|---|---|
| R. Appleby | WP5: status and plan | UNIMAN |
| A. Bertarelli | Baseline for cryo-collimators | CERN |
| A. Lechner | Energy deposition with cryo-collimators in IR2 (ions) and IR7 | CERN |
| R. Kwee | Background studies for different HL-LHC options | RHUL |
| A. Marsili | Simulated cleaning for HL-LHC layouts with errors | CERN |
| M. Serluca | Comparison Merlin/Sixtrack and first HL-LHC results | UNIMAN |
| N. Simos | Irradiation tests at BNL for collimator materials | BNL |
| L. Lari | Collimator failure losses for various HL-LHC configurations | CSIC |
| J. Resta | Update on non-linear collimation schemes | CSIC |
| W. Scandale | Final layout and plans for crystal collimation tests at LHC | LAL |
| G. Stancari | Progress towards the conceptual design of a hollow electron lens for the LHC | FNAL |
| T. Markiewicz | RC collimator design: prototyping experience and LHC prospect | SLAC |

# Simulation workshop tomorrow

**BDSIM**

A fast tracking library built with C++ and for GEANT4, allowing particle tracking in vacuum, essentially optical tracking, around the LHC lattice alongside secondary showers from G4. Under development by RHUL.


**MERLIN**

Similar to philosophy to Sixtrack but as a flexible C++ library. Comes with more realistic scattering and parallel operation. Under development by Manchester/Huddersfield in a very modular, easily extendable, way. Tracking is currently 4D.

Various codes for collimation studies - many new simulation challenges

**LHC@home SixTrack**

Our 'standard' halo tracking tool, with models of collimator scattering. Written in FORTRAN. Essentially 6D symplectic tracking with a K2-inspired non-inelastic scattering model.

**FLUKA**

Shower code capable of tracking second showers down to low energy, and through magnetic fields. Big library of LHC components in its geometry language.

**R. Appleby**

*We will put together the status of available tools and ongoing collimation study challenges.*

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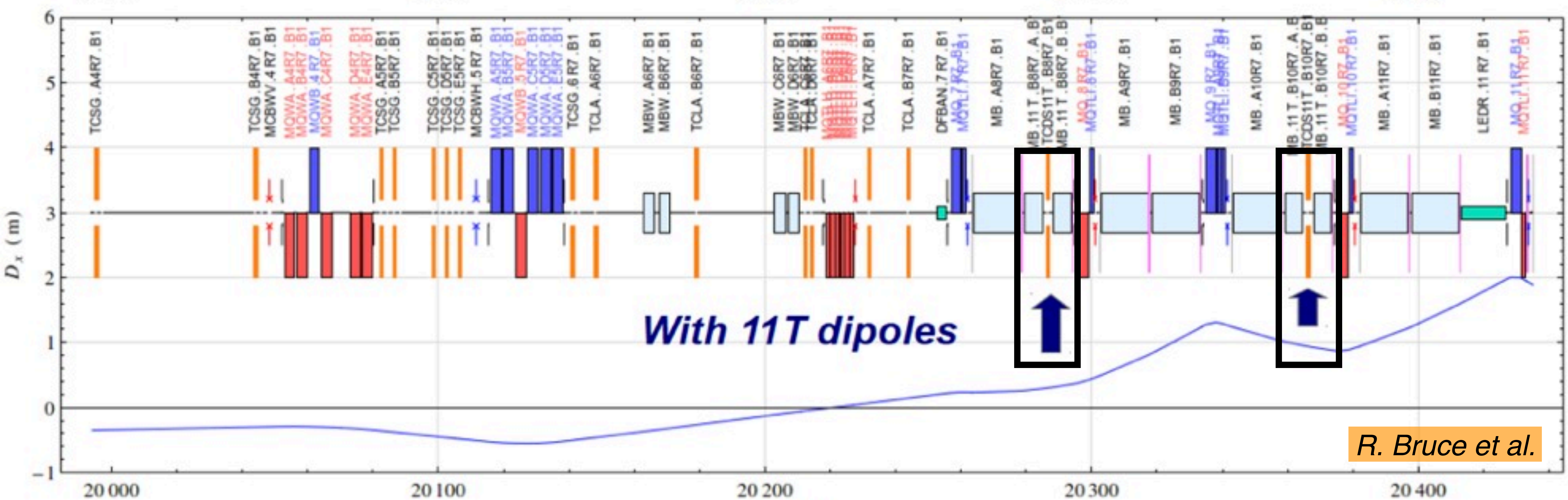
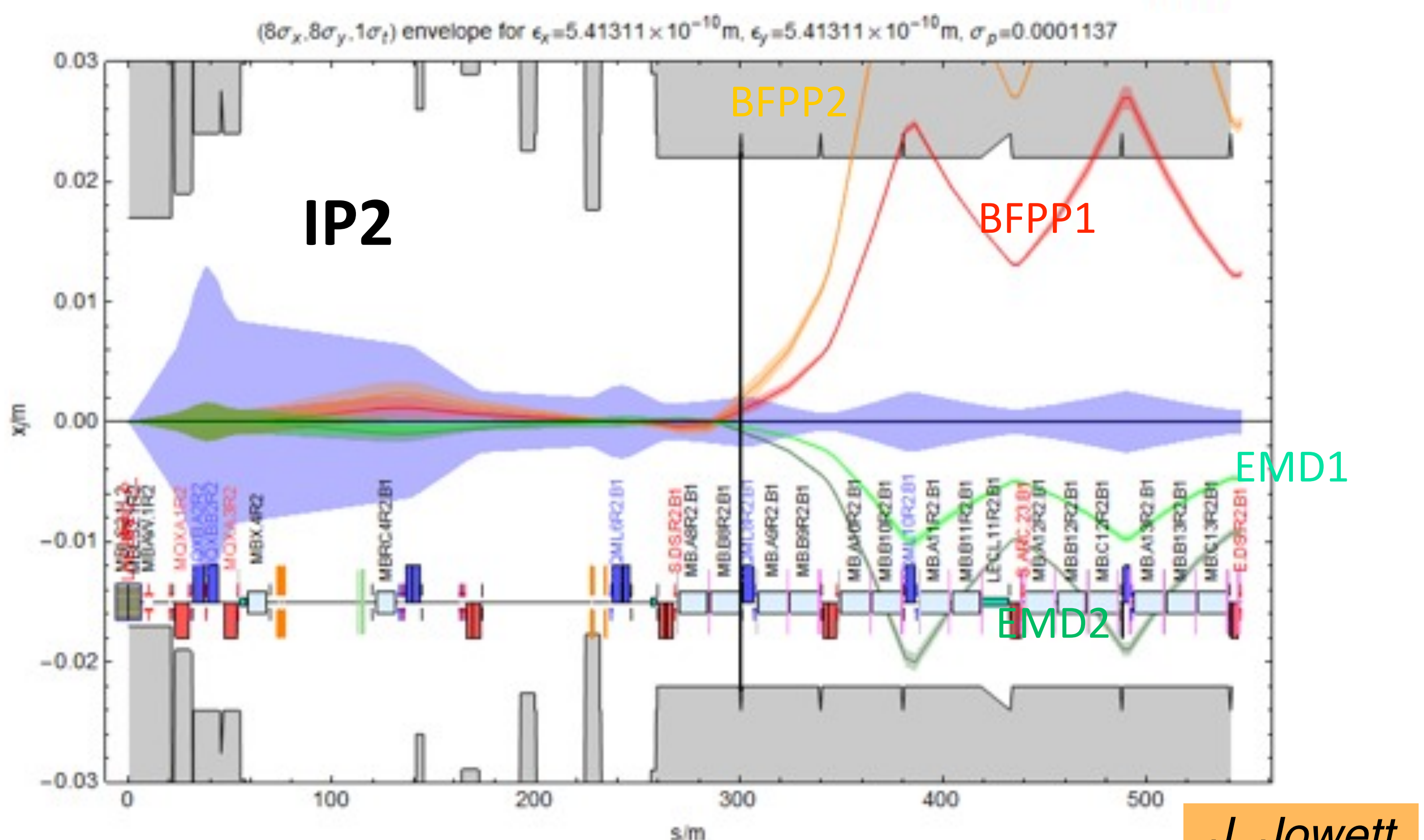
- ☑ **HiLumi-WP5 activities**
- ☑ Other collimation activities
- ☑ Conclusions

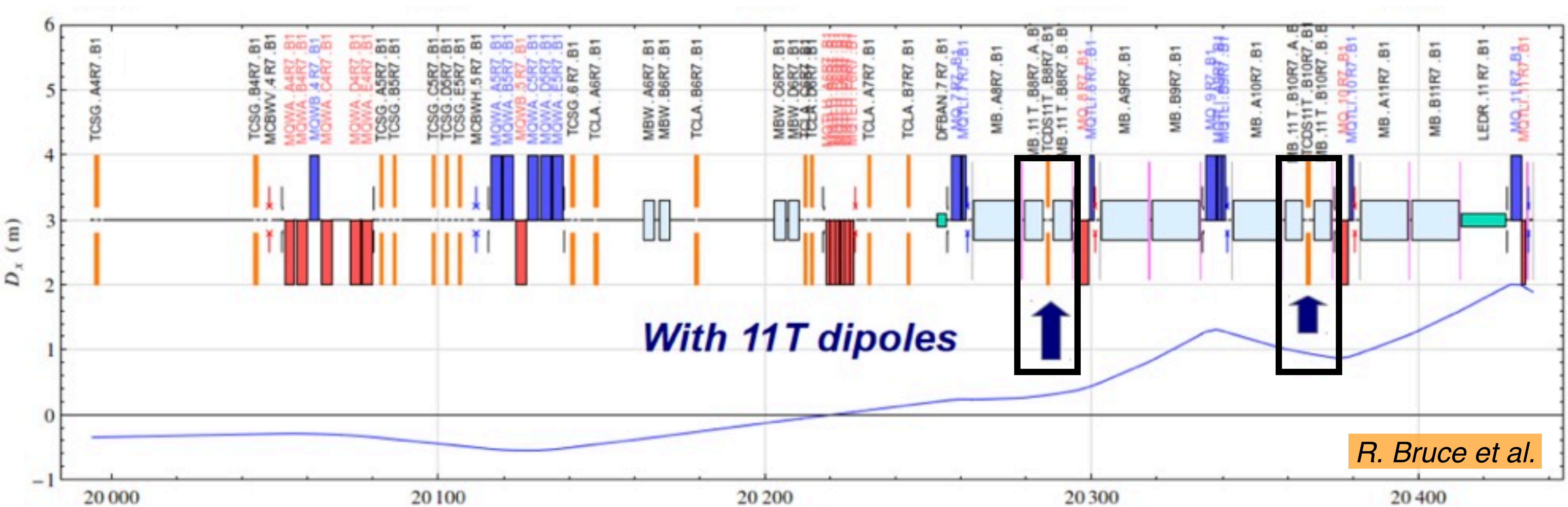
# Final layouts for DS collimation

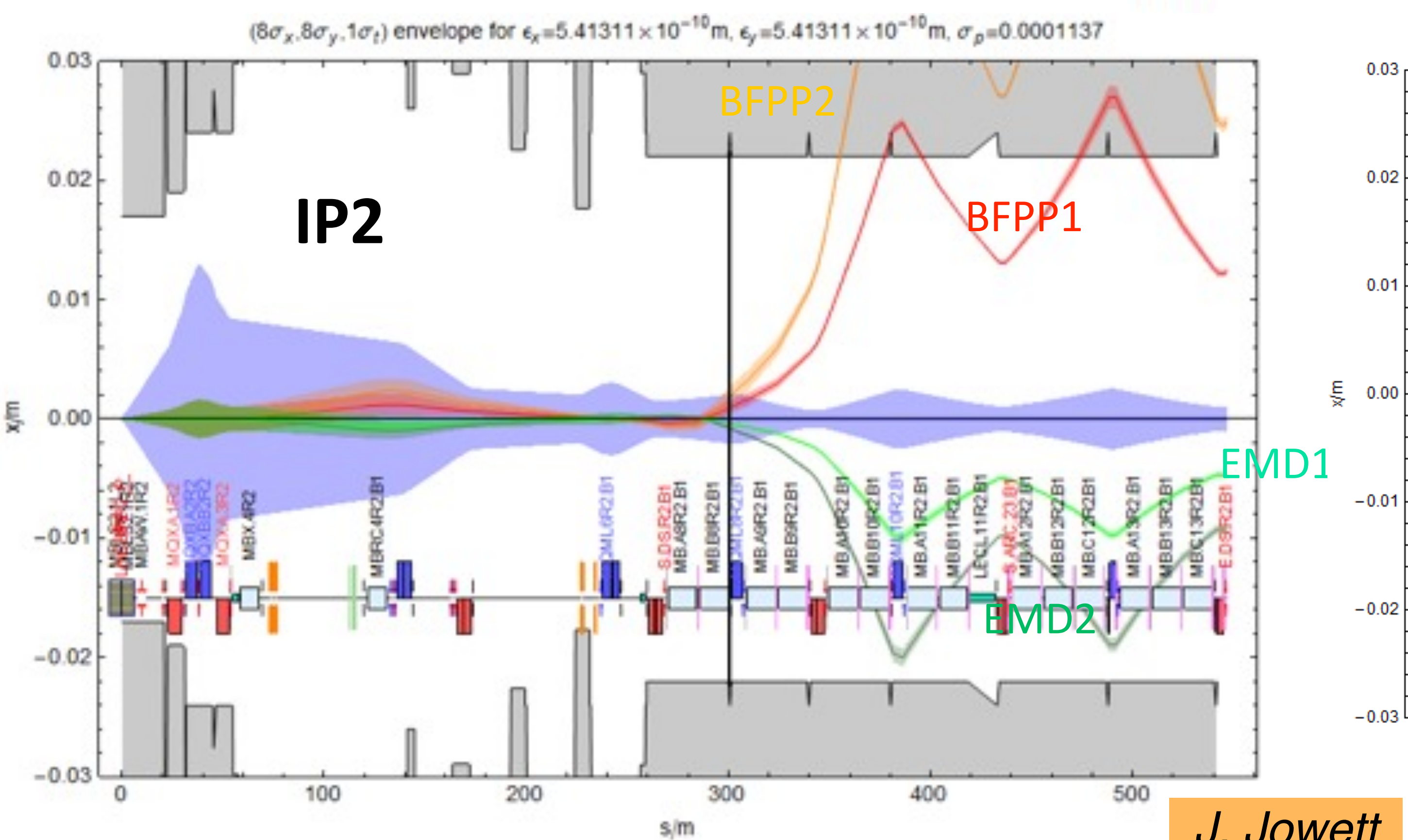


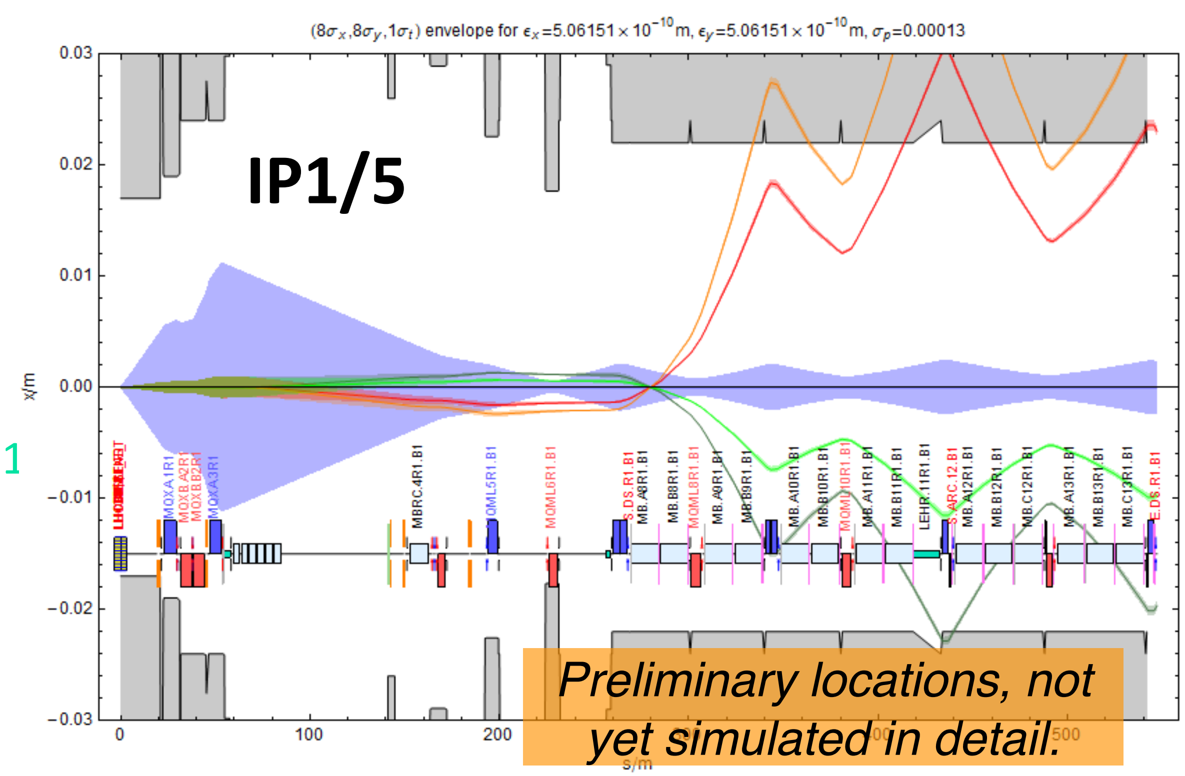




Layouts defined and validate, starting with higher priority points first: IR2-ion (presented at the May review), IR7 (presented here), IR1/5-ion upcoming.

# Final layouts for DS collimation

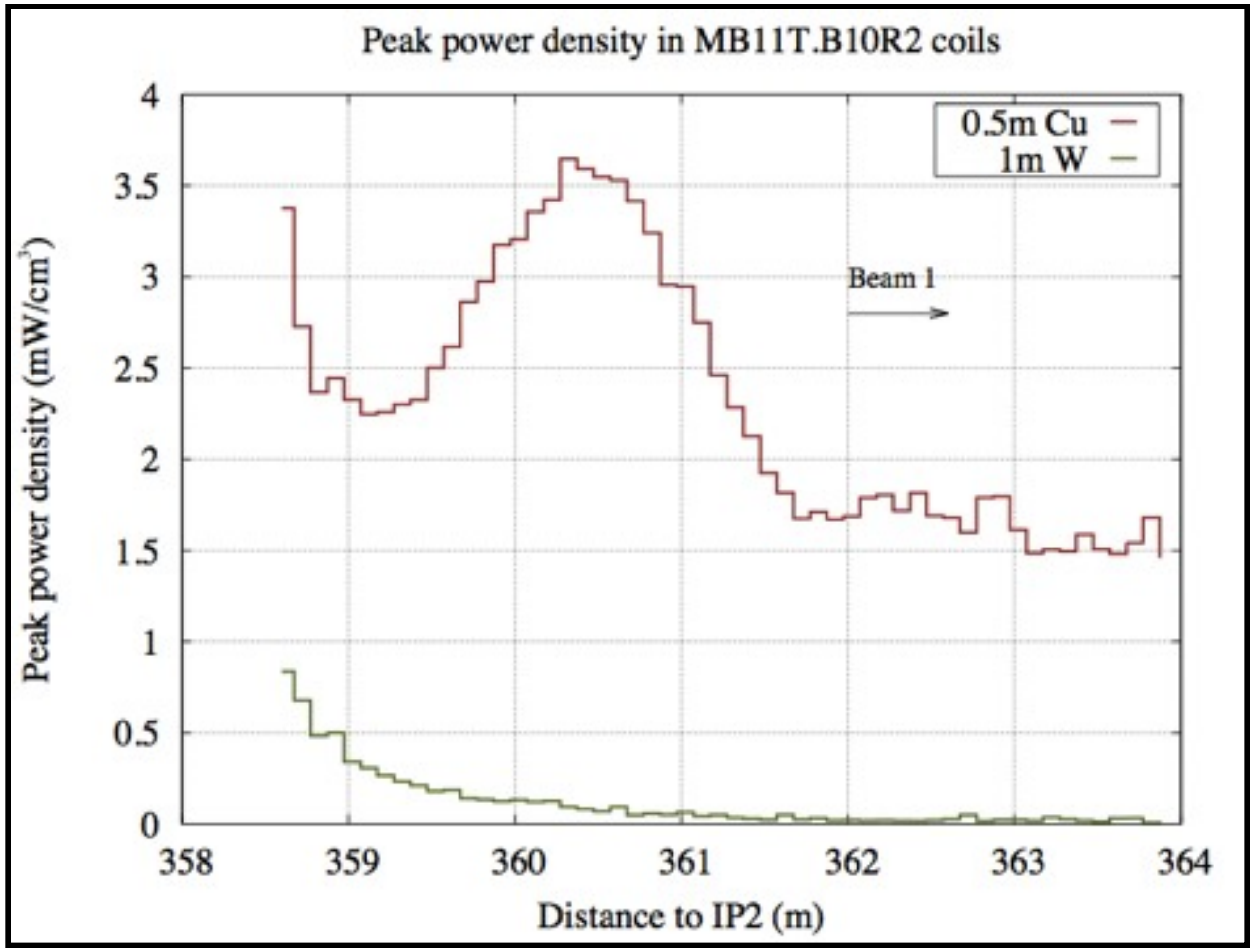


# Gain factor from local DS collimation

## Ions - IR2

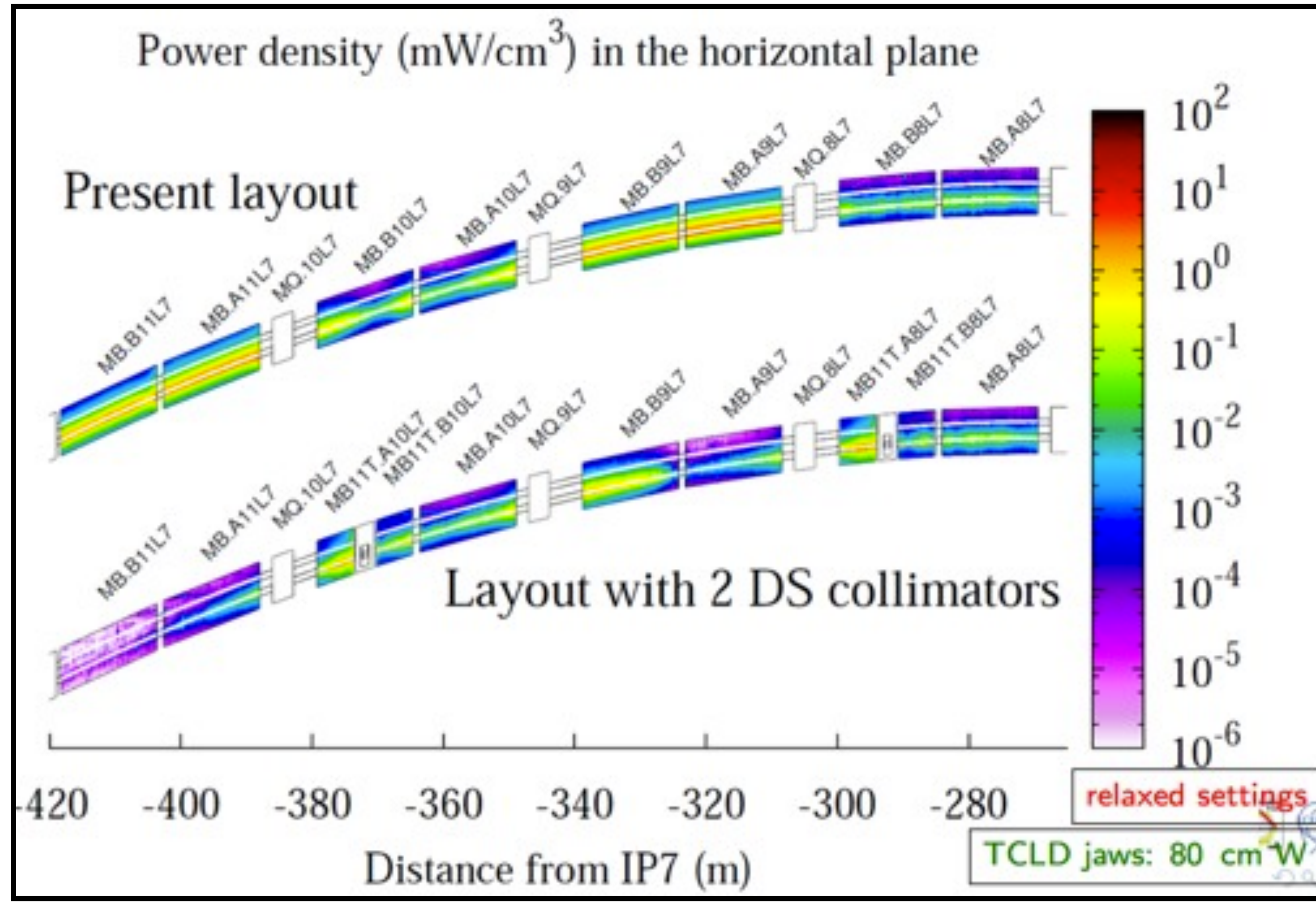



- 11T dipole downstream of TCLD: peak power density in coils for 6× design lumi ranges from 0.8 mW/cm$^3$ (1 m W) to 3.7 mW/cm$^3$ (50 cm Cu)

Gain factor > 25

**A. Lechner**

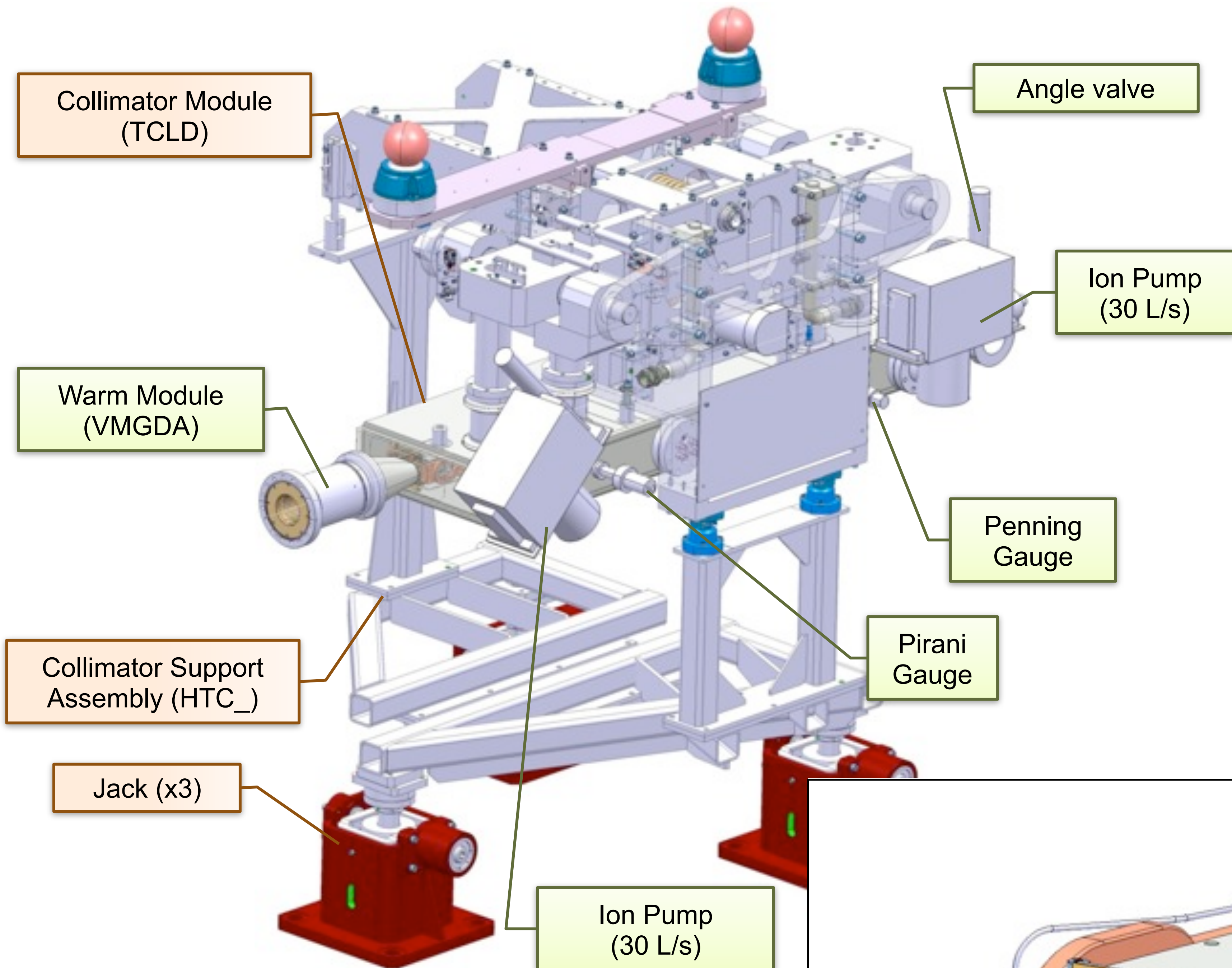
## Protons - IR7




Gain factor ~ 10

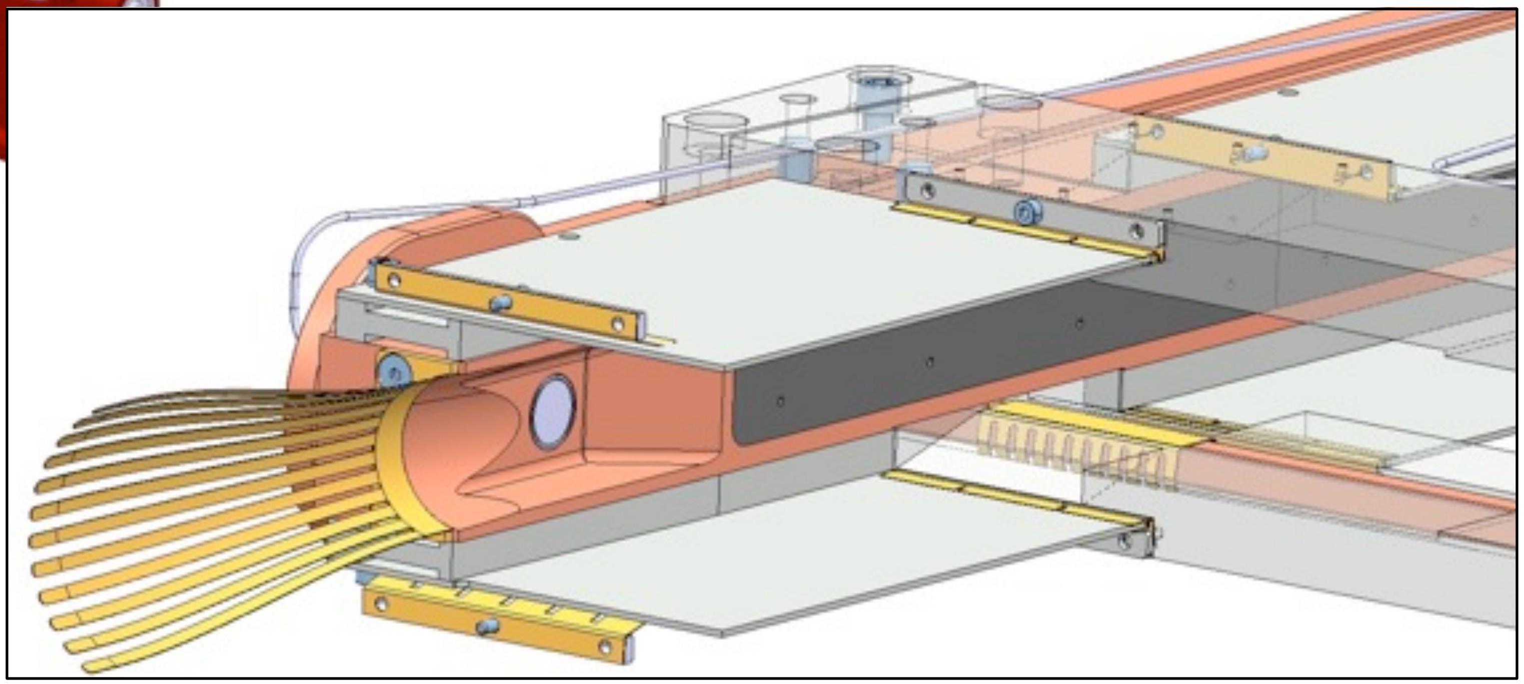
**Need to compare the new results with updated quench limits for the 11 T dipole.**

# TCLD design and length definition



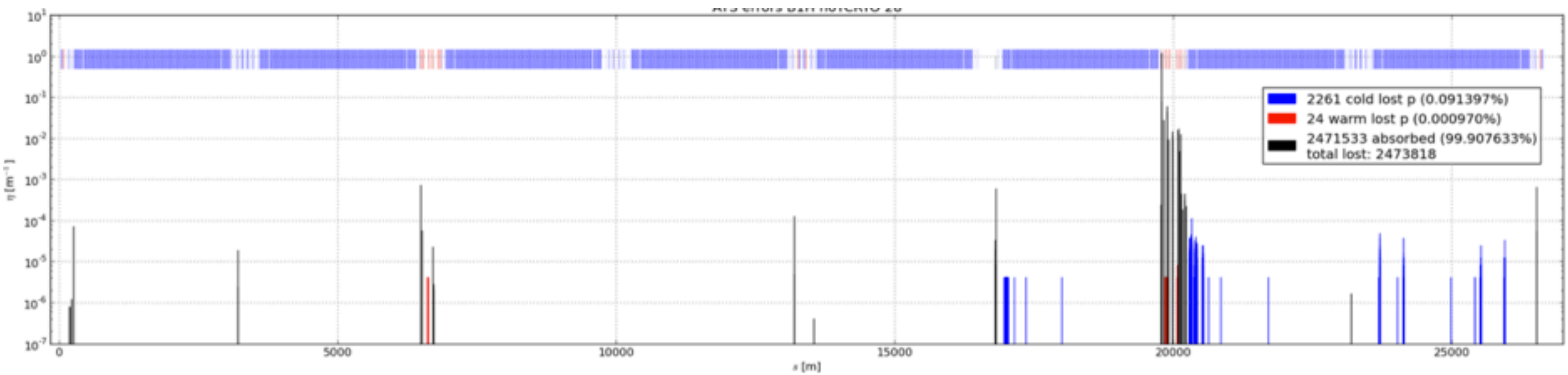

***Agreed on a baseline of 80 cm!***

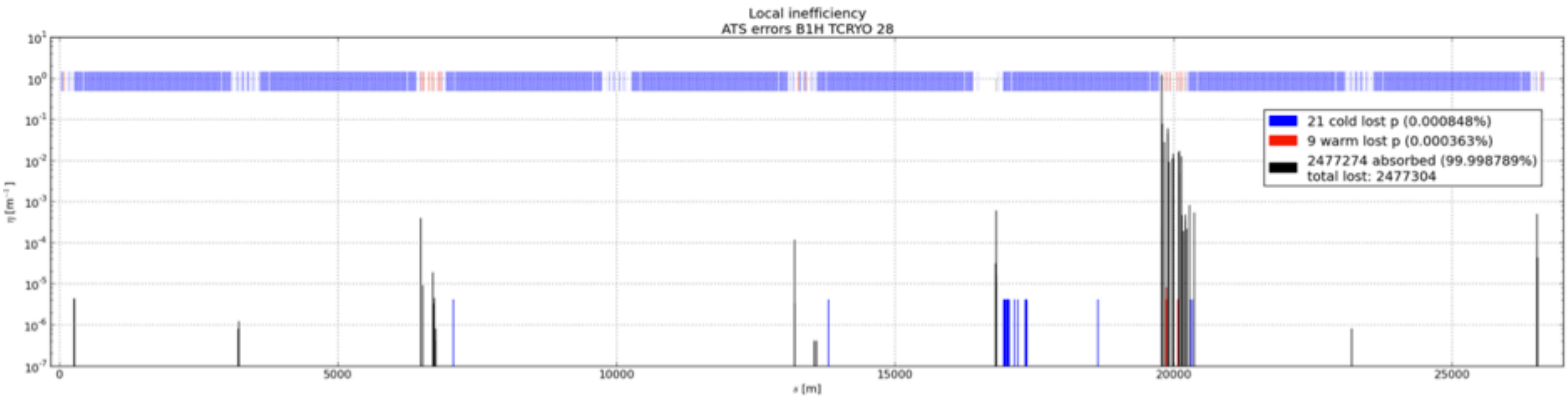
**Now: required detailed integration study between 2 11T dipole!**



***A. Bertarelli***

# Cleaning performance with errors

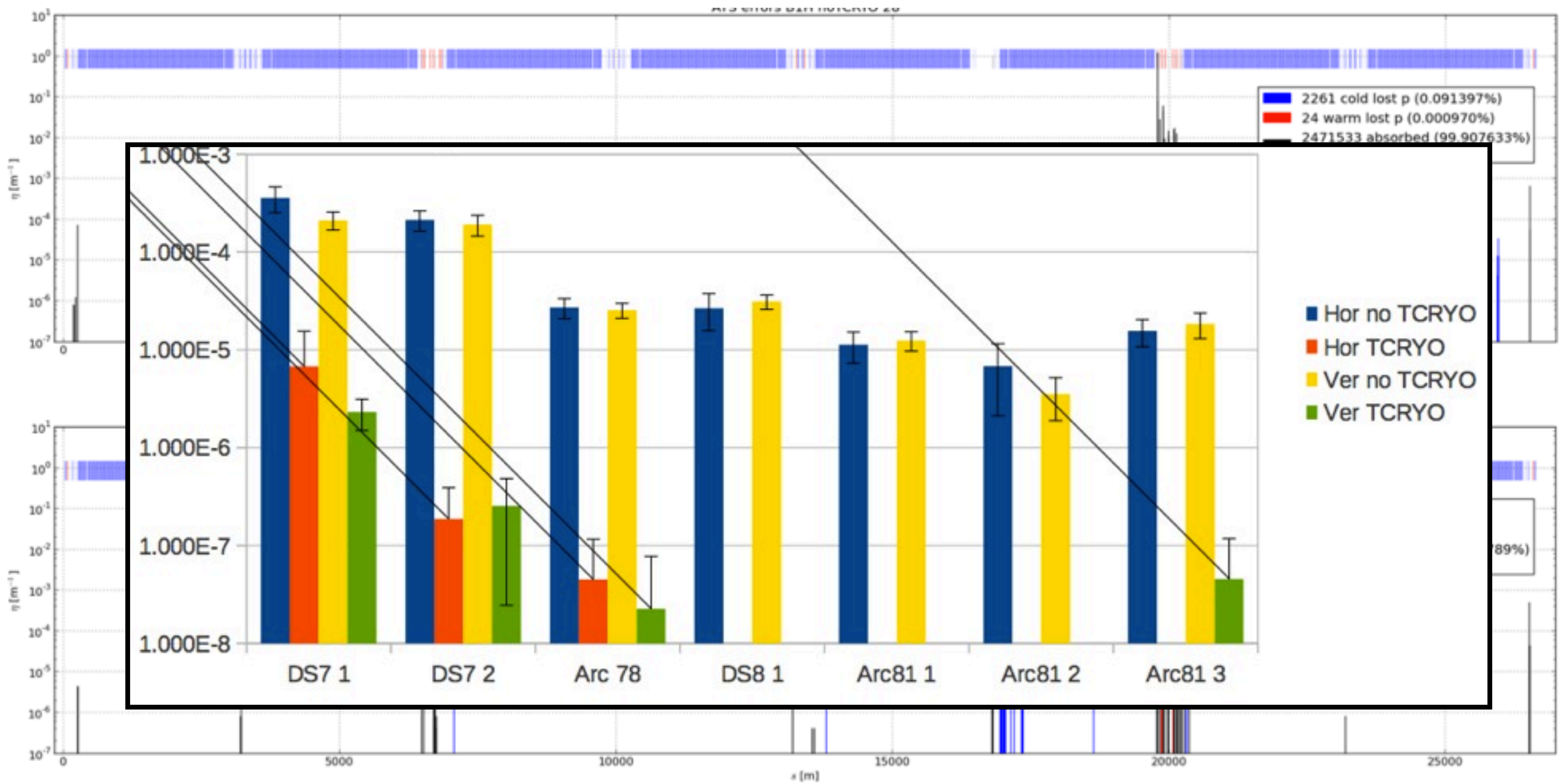



***A. Marsili***

*Catching dispersive losses in IR7 with TCLD collimators improve losses around the ring and makes machine less sensitive on errors.*

# Cleaning performance with errors

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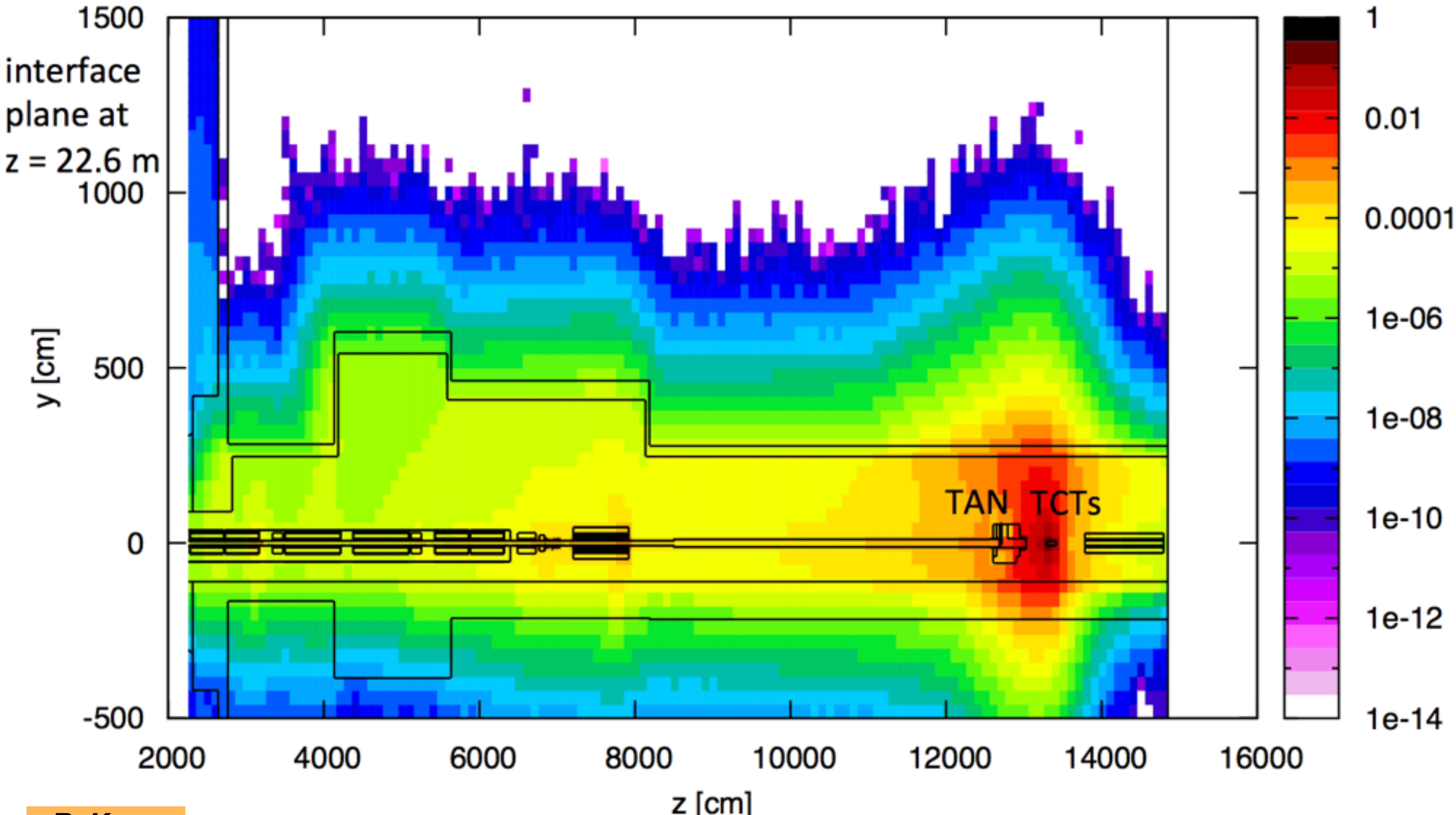
*Catching dispersive losses in IR7 with TCLD collimators improve losses around the ring and makes machine less sensitive on errors.*

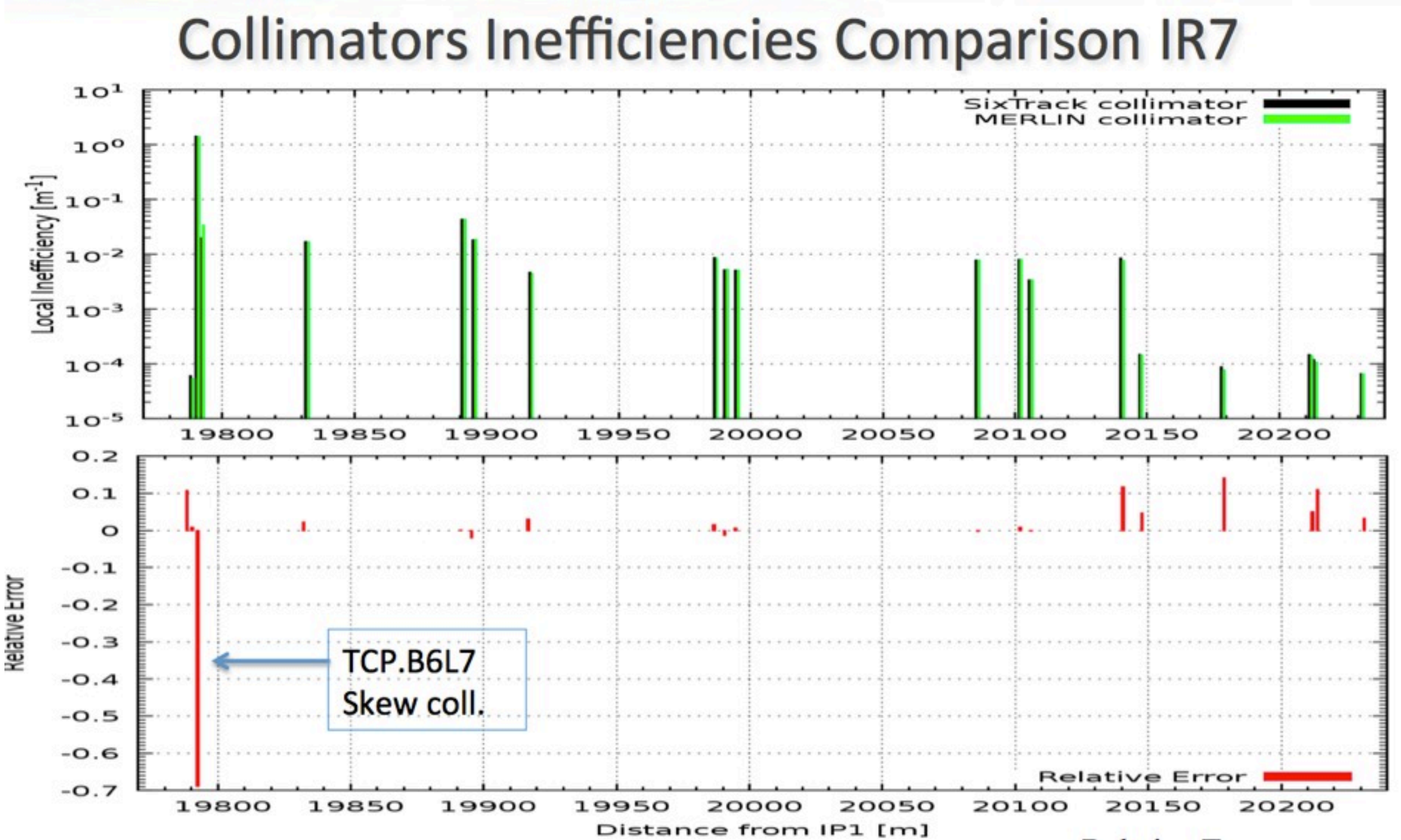
# First background studies for HL-LHC




**R. Kwee**

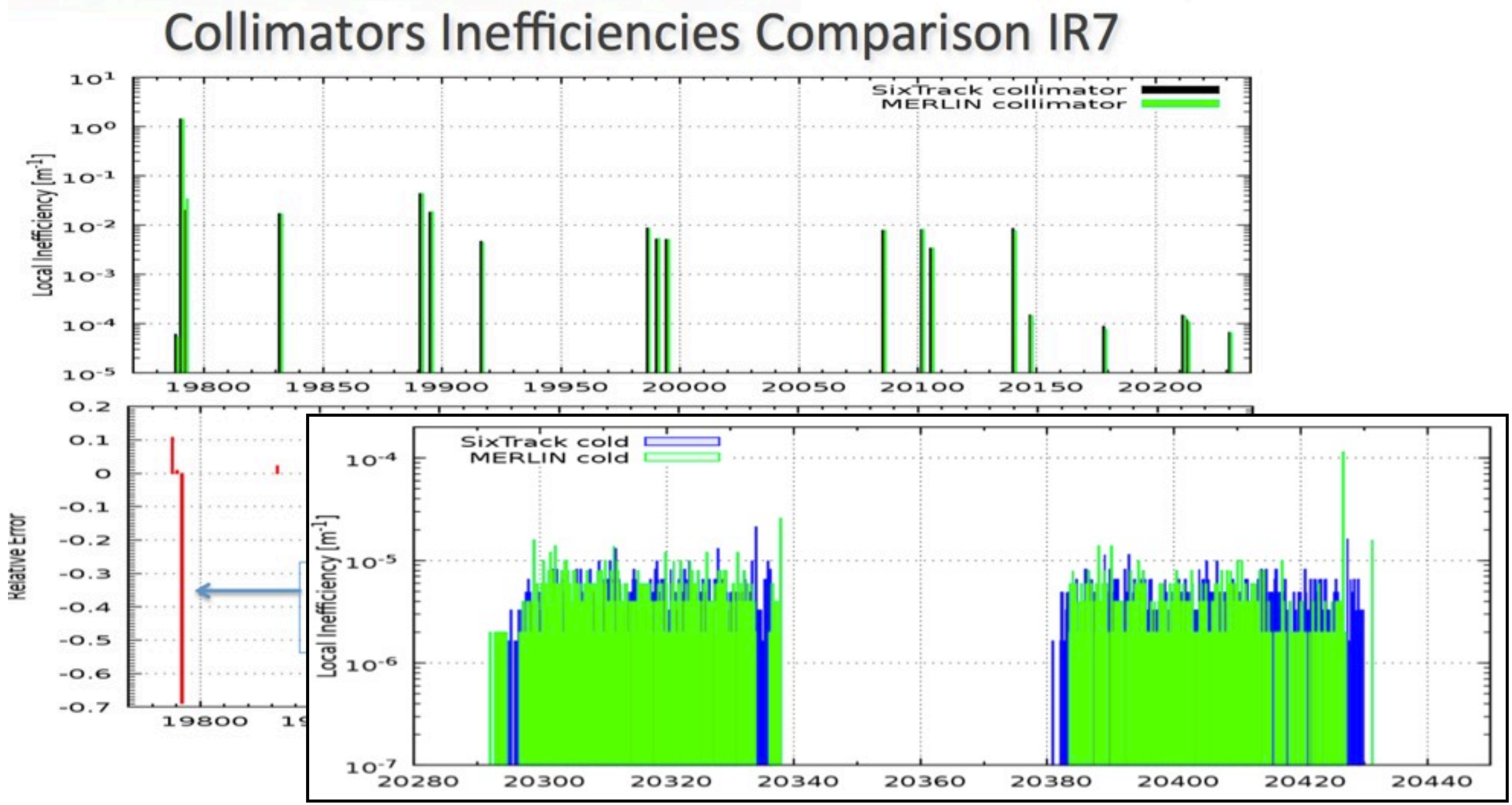
***Preliminary results that will be part in our D5.4. Need to be repeated following the layout evolutions.***

# Merlin / Sixtrack comparison




M. Serluca

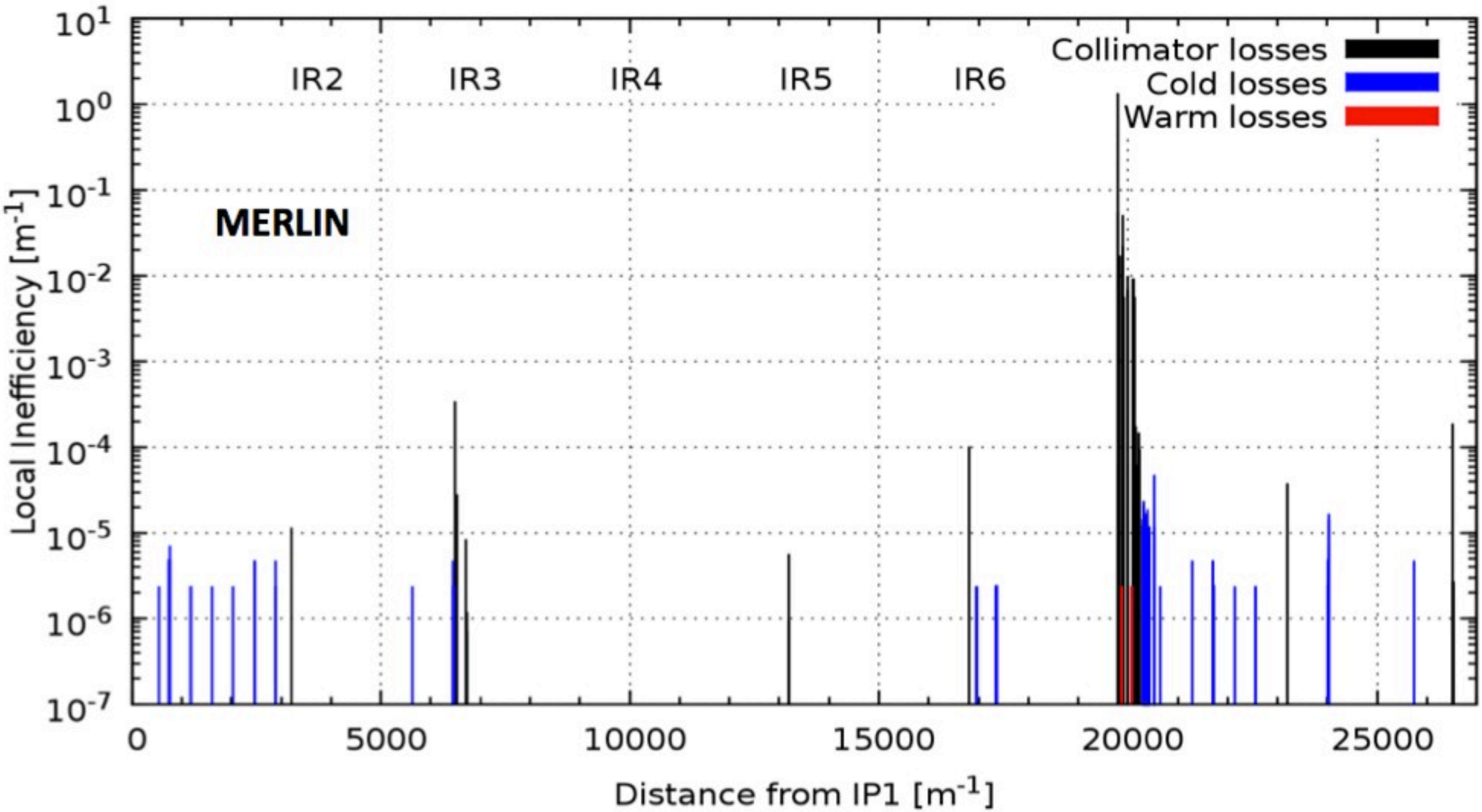
# Merlin / Sixtrack comparison




**M. Serluca**

Very nice results, but some details of comparison still need work.
**Need to work with high priority on getting 6D simulations!**
**Looking forward to have the new scattering routine available.**

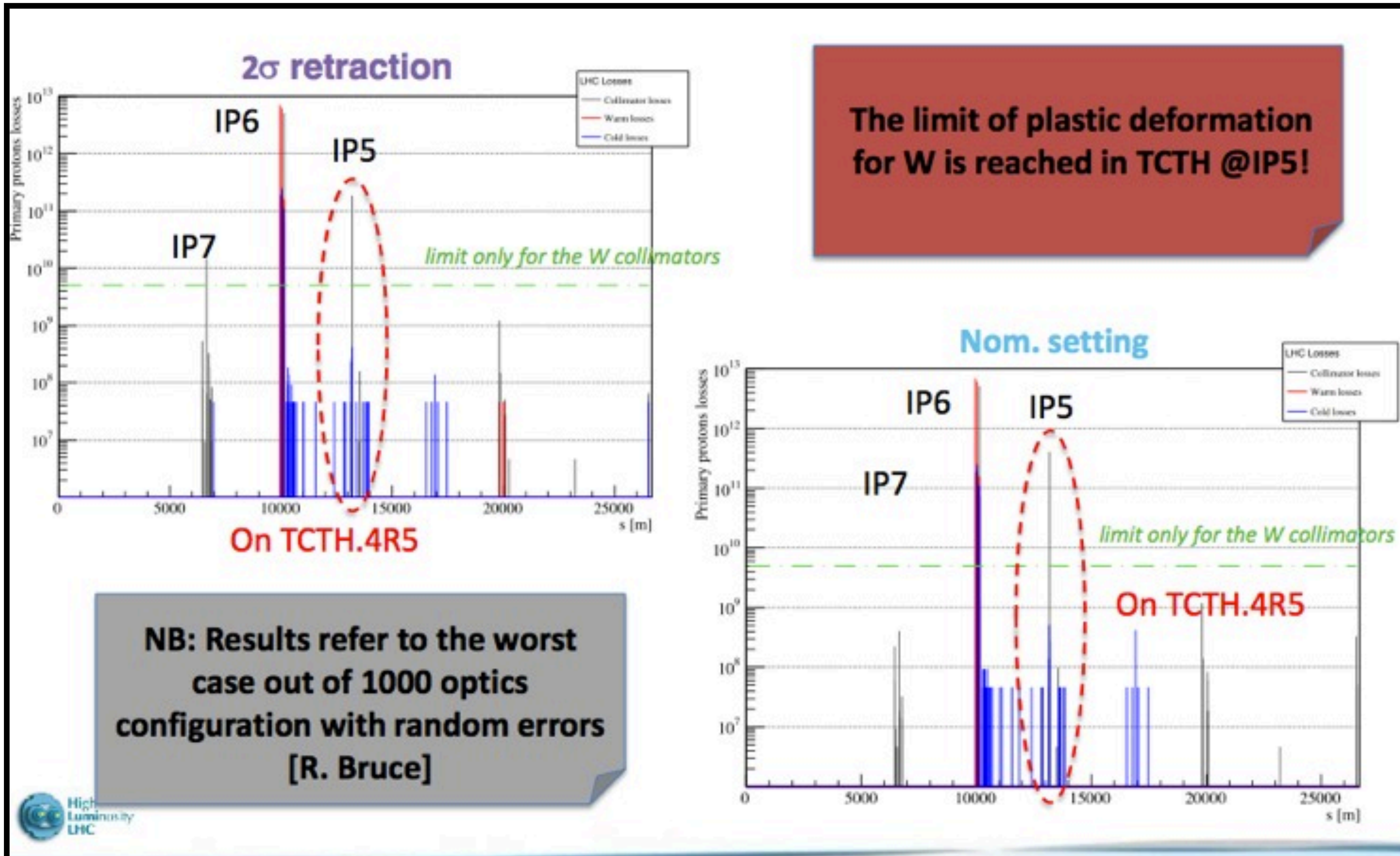
# First loss maps for ATS pre-squeeze




**M. Serluca**

# Loads on collimators for fast failures

For **Beam1** and **Beam2** → ***Setting*** and ***Orbit*** and ***Optics*** errors considered




**L. Lari**

*Feedback on optics design and collimator material choice.*
*Concluded that we can use standard materials for the TCLD collimators.*

# Outline

- ☑ Introduction: HiLumi-WP5
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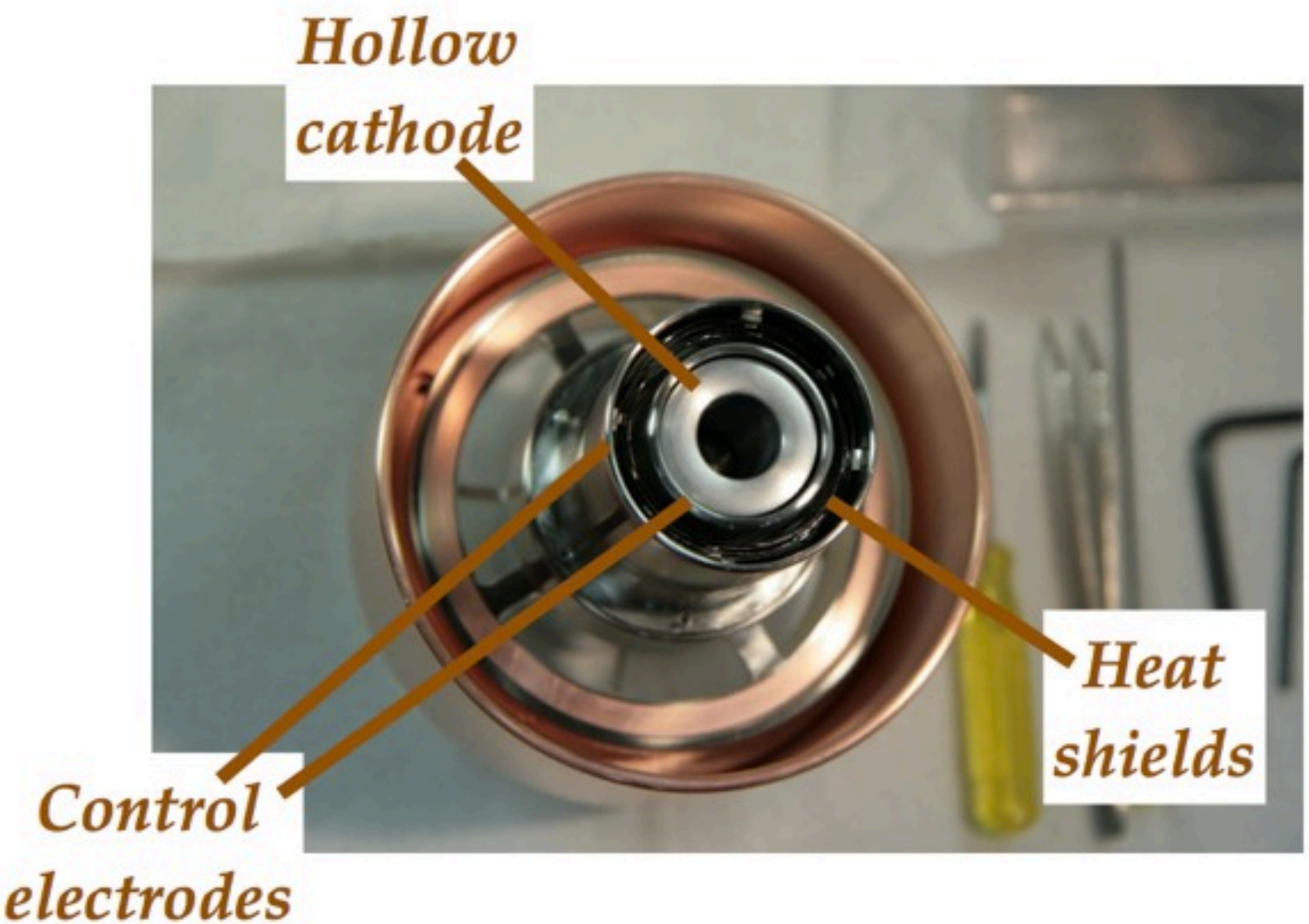
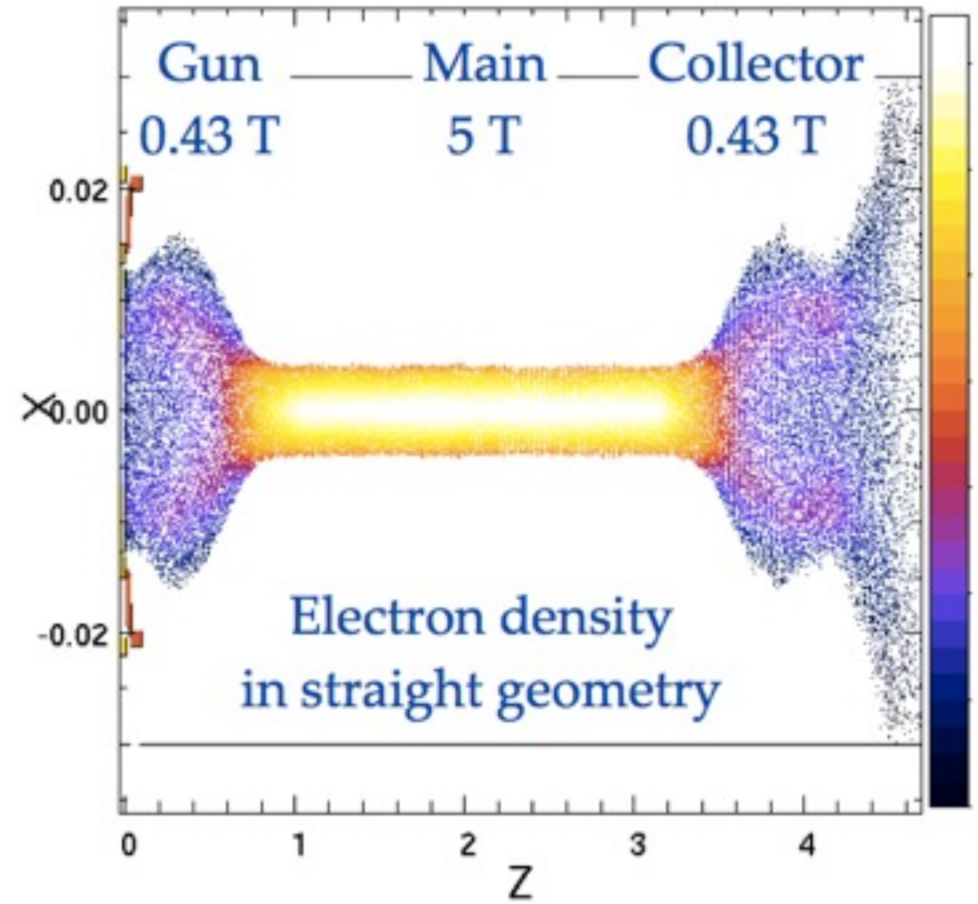
# Other collimation activities

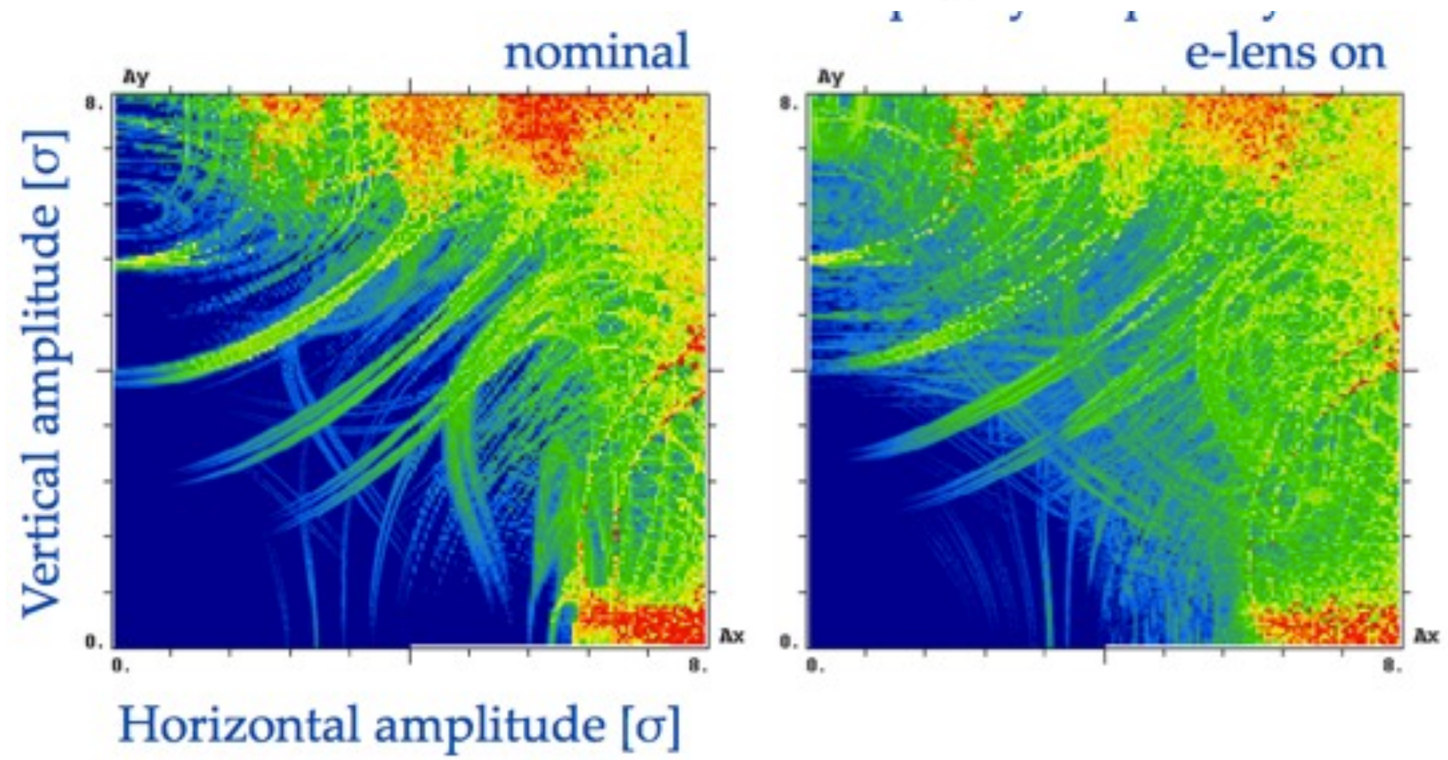
Status of four important collimation activities

- **Irradiation tests at BNL (N. Simos)**
  **Crucial for us**: MoGr - candidate for next generation of secondary and tertiary collimators - is being tested.
  Nick warned about possible risks of MoGr "delamination" in case of high doses.
  Major hiccup during 2012 irradiation campaign: one sample damaged.
  Irradiation will be completed in 2013 at the beginning of the RHIC run.
- **Crystal collimation studies (W. Scandale)**
  Baseline layout folly defined, clear plan for first beam studies.
  LHC Engineering Change Request out for approval 2 days ago!
- **Hollow electron lens studies (G. Stancari)**
  Very good progress on the conceptual design report, including experimental results.
- **SLAC rotatory collimator (T. Markiewicz)**
  A couple of emblematic photographs.

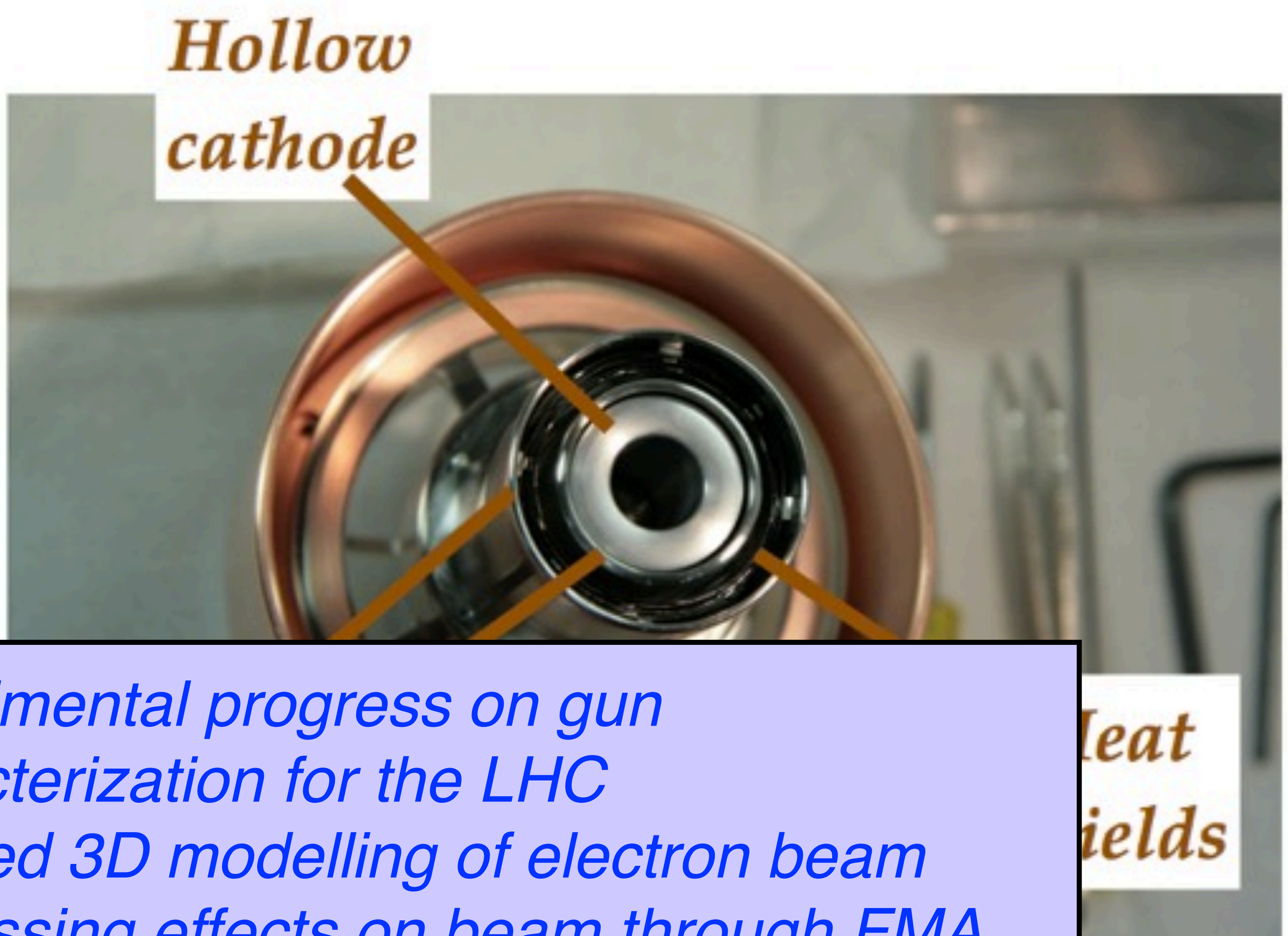
# Hollow e-lens studies and tests



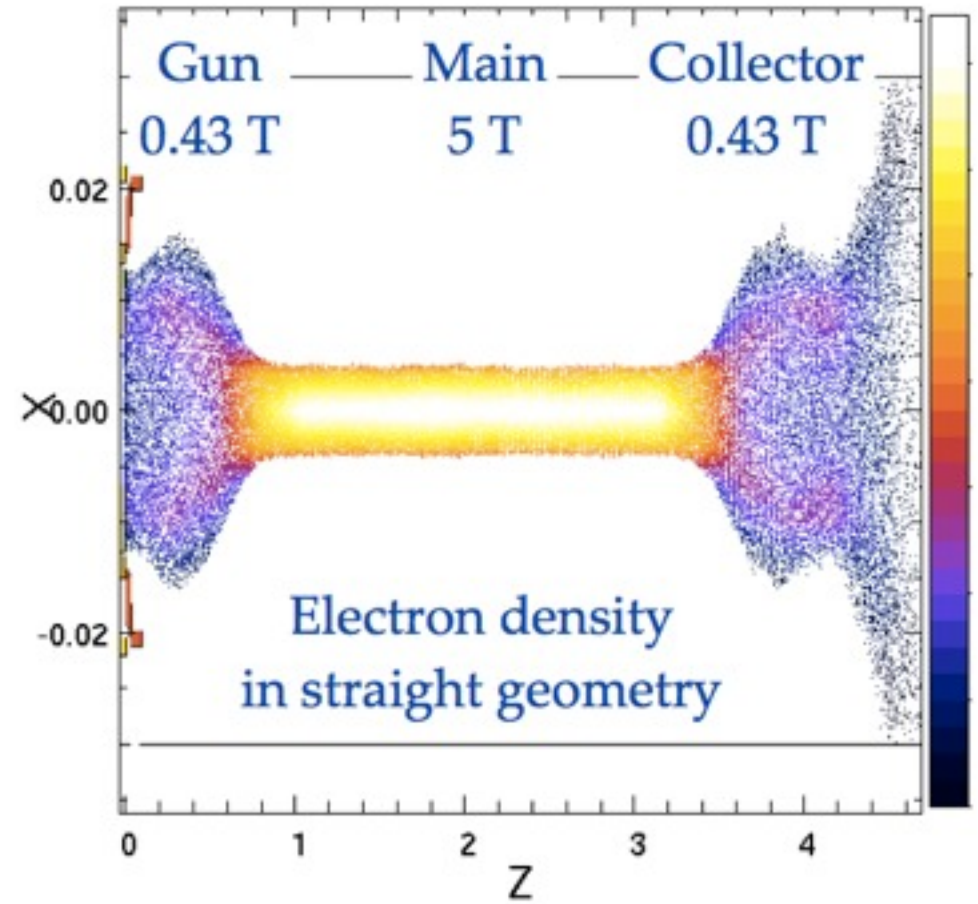



# Hollow e-lens studies and tests

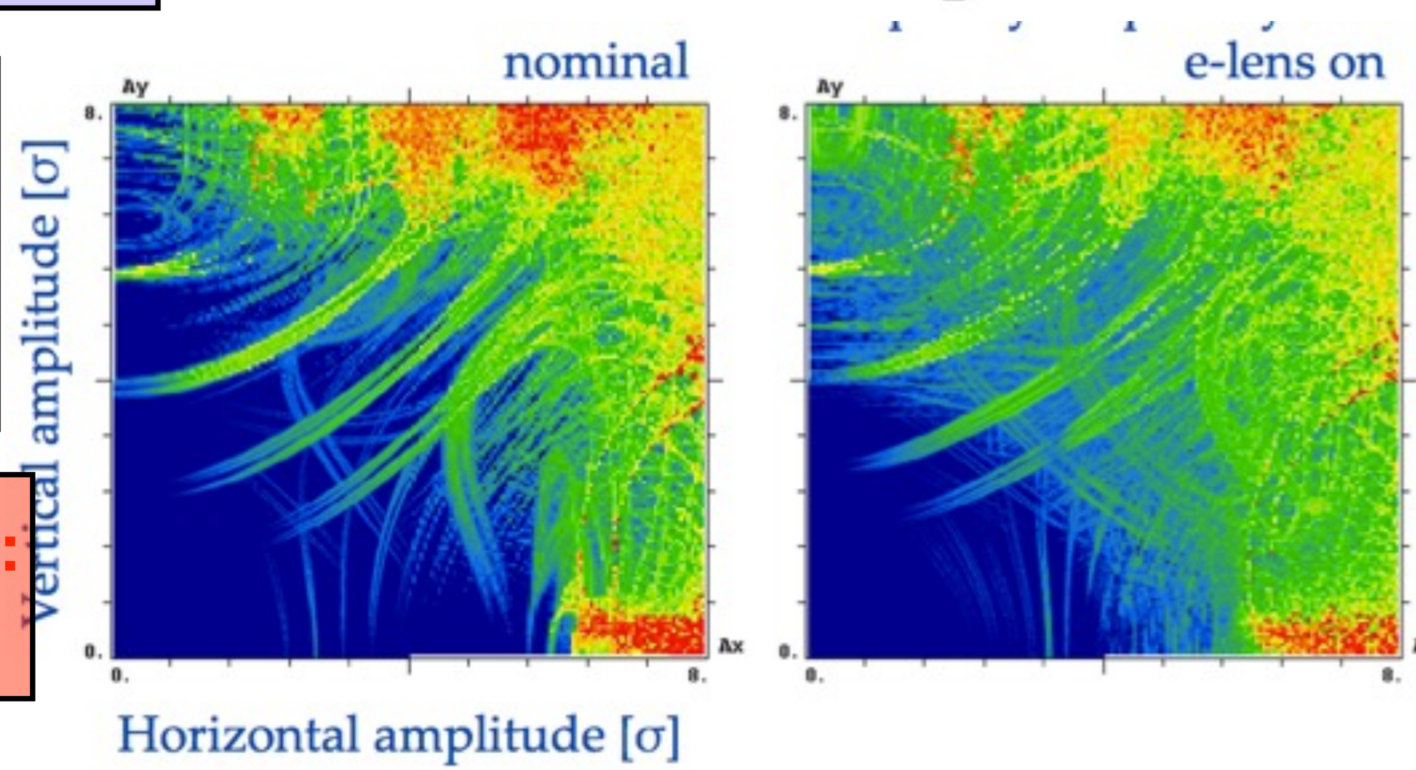



*Experimental progress on gun characterization for the LHC*
*Detailed 3D modelling of electron beam*
*Addressing effects on beam through FMA*




Conceptual design report on preparation: now need work together with CERN (BI, MME, Coll) for design report in 2014.

**Entering critical phase for manpower: looking for good students!**



# Status of SLAC rotatory collimator

LARP

After that, wind 2nd mandrel, then …………..

- Prep with strips & braze coils and inner hub/shafts to mandrels (2 of 2 done)
- Machine assembly round & concentric to axis at diameter to accept Glidcop jaws
- Machine & Cu plate Glidcop jaws
- Prep and braze jaws to mandrels (2nd done 8-Apr-13)
- Machine facets, end features (2nd done 28-May-13)

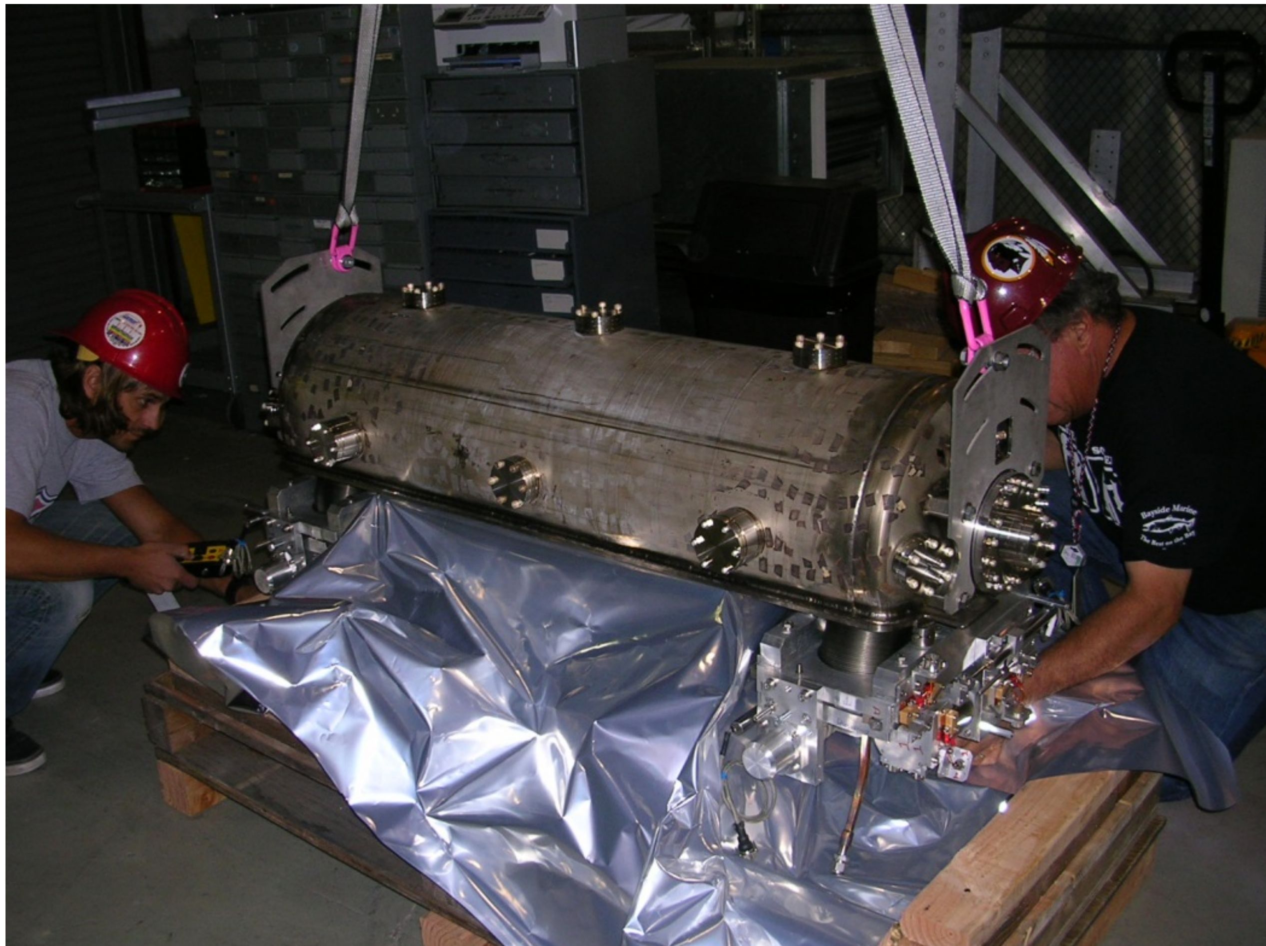
SLAC

- Install RF bearing housing → Began 3-June-2013
- Install shaft support bearings and rotation drives
- Test prior to installation in vacuum system
- Prep existing vacuum base plate to receive new collimators
- Mount, align & test → Began 6-Sept-2013

SLAC?

- Decide details of how vacuum cover will be attached to vacuum base plate & machine appropriately
- Mate cover & baseplate
- Test rotation after welding, pre and post vacuum
- Vacuum bakeout Plasma cleaning → Began 16-Oct-2013
- Test after Plasma Cleaning

# Status of SLAC rotatory collimator



SLAC?

- ~~Mount, align & test~~ → Began 6-Sept-2013
- ~~Decide details of how vacuum cover will be attached to vacuu~~m base plate & ~~machine appropriate~~ly
- ~~Mate cover & base~~plate
- ~~Test rotation after welding, pre and post vacuum~~
- Vacuum bakeout ~~Plasma cleaning~~ → Began 16-Oct-2013
- ~~Test after Plasma Cleaning~~

*Many thanks for the continued effort!*

Need to establish a plan for comprehensive testing without and with beam (CERN+US-LARP)

# Conclusions

- The recent results from HiLumi-WP5 and other collimation related activities were reported.
  - *Recalled the WP5 structure and main activities, and links to other ongoing LHC collimation upgrade works.*
- Many thanks to the speakers of the parallel and joint sessions!
  - *12 talk in parallel WP5 sessions.*
  - *4 related talk in a joint session with WP2/3/4.*
- Progressing well on the DS collimation studies
  - *Following recommendation of our May, we addressed key layout studies, with priority to points 2 and 7!*
  - *Goal: be able to review the situation and take critical decisions in 2015!*
  - *Important contributions from CERN partners!*
- Status of our simulation tools will be discussed tomorrow at a WP5 simulation workshop at Daresbury.
- Important progress also on crystal collimation, hollow elens studies and rotatory collimator hardware.

# Thank you for your attention